

# Cementing Our Future

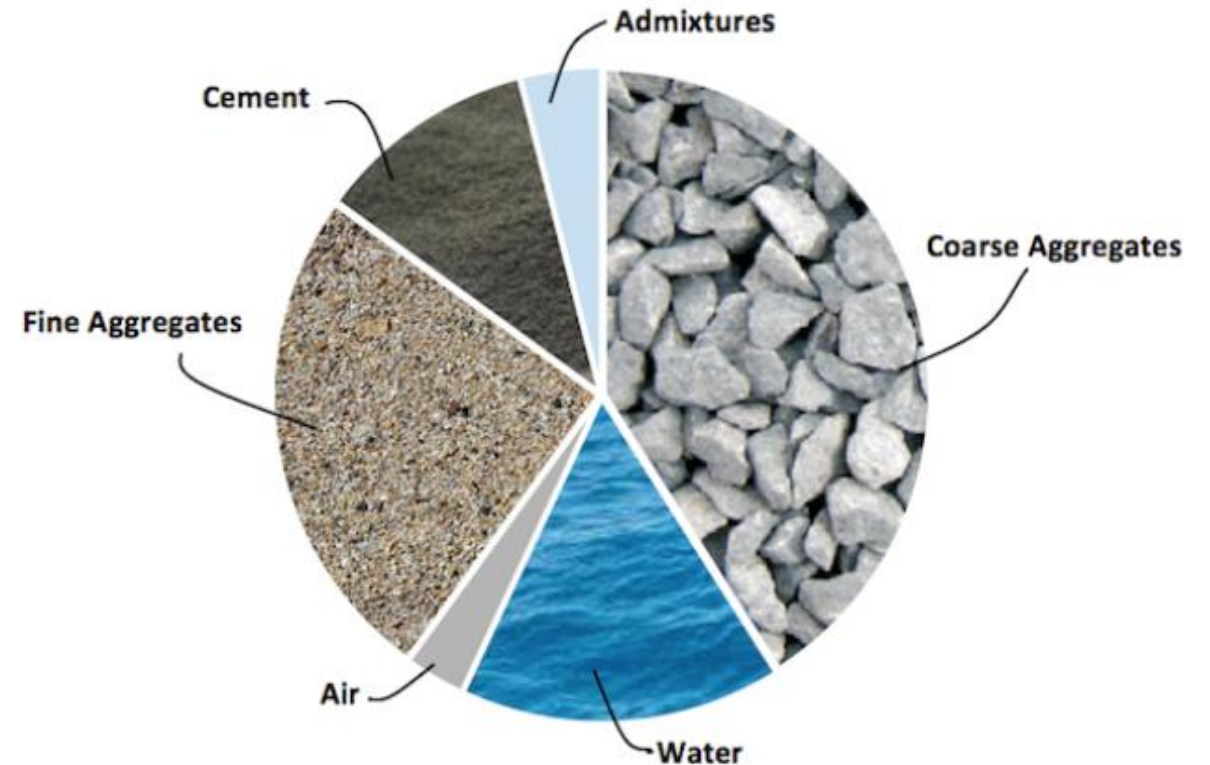
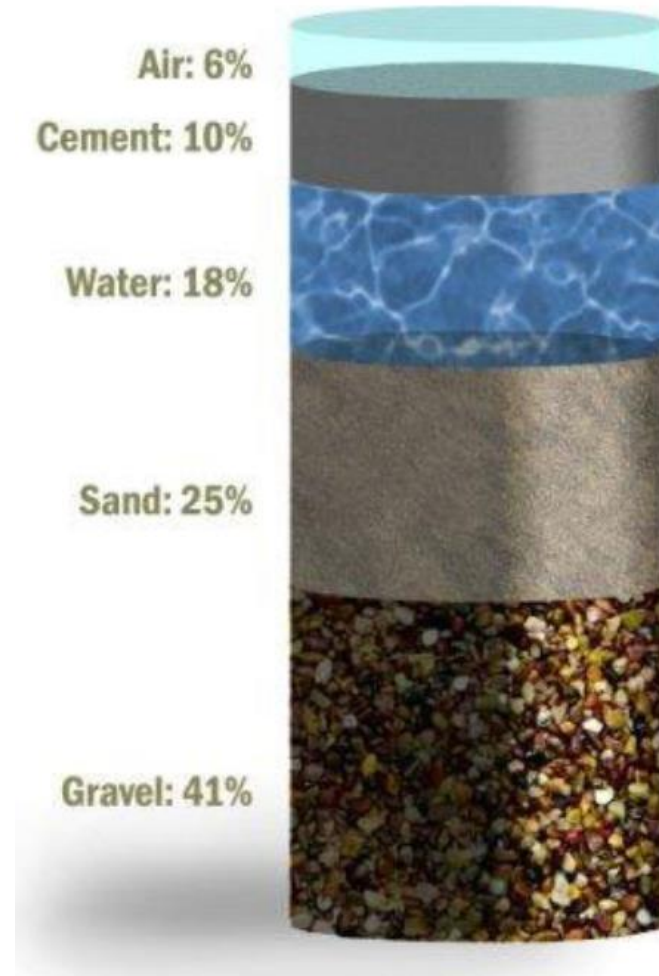
When Endurance Matters

Joseph King

March 13, 2018

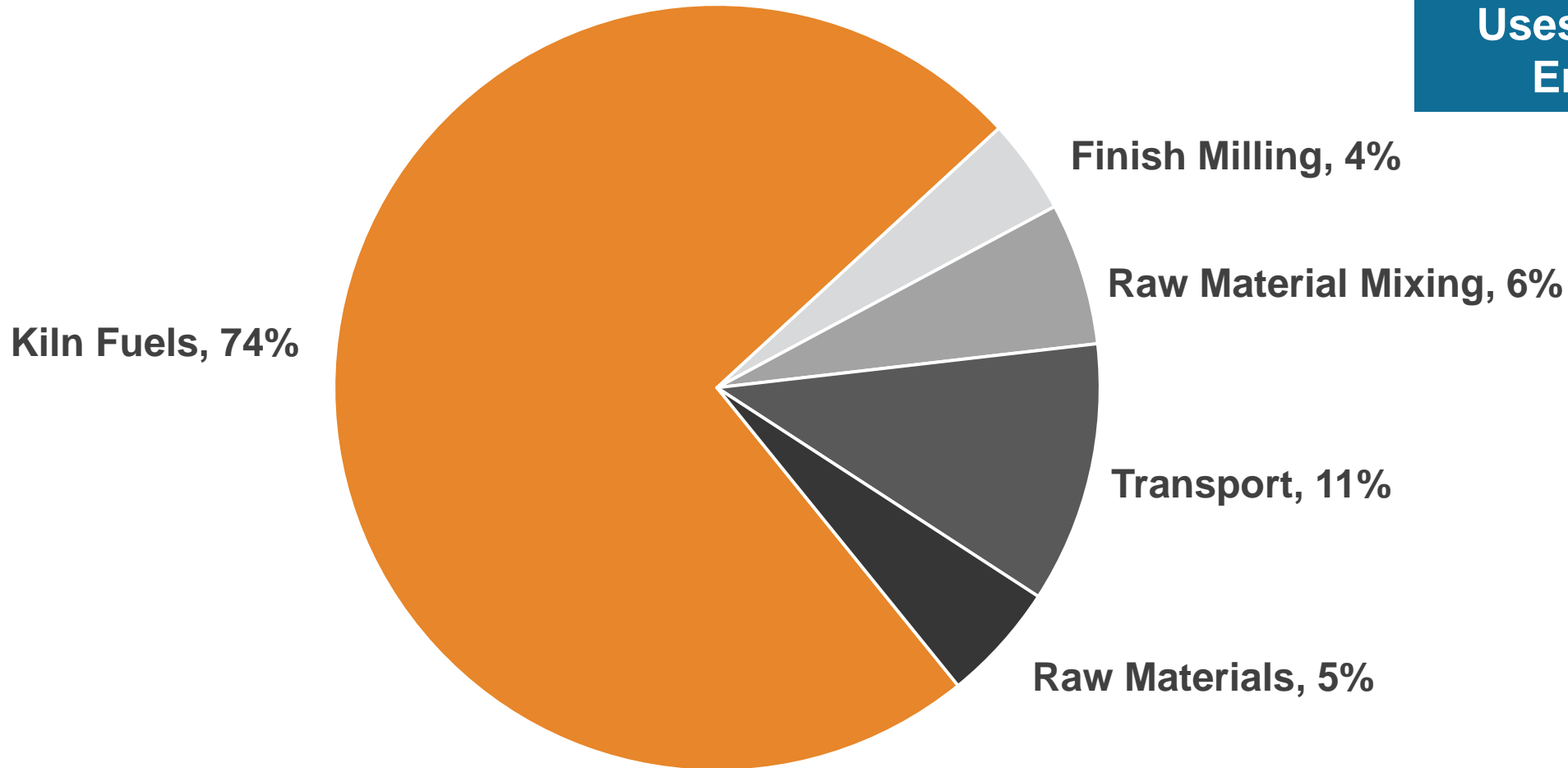


# Cement, Concrete and Aggregate



# Cement Kilns Drive Energy Use



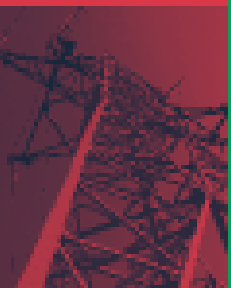
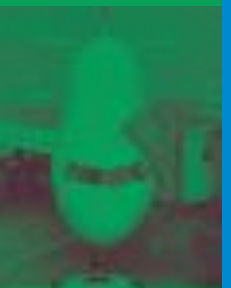
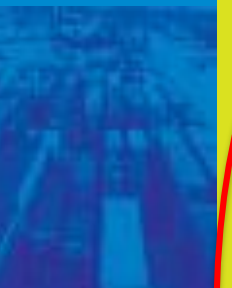
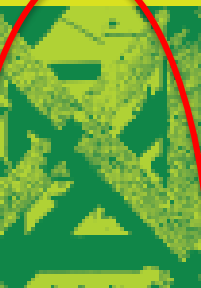
**U.S. Cement Industry  
Uses ~0.450 Quads of  
Energy Annually**



# ASCE 2017 Infrastructure Report Card: **D+**

## Concrete Spans All These Application Sectors:\*

*Includes the critical highways, bridges, commuter rail, and transit systems*

	 Surface Transportation	 Water & Wastewater	 Electricity	 Airports	 Waterways & Marine Ports	 All Sectors
<b>Investment Needs – 2016 through 2025</b>	<b>\$2,042</b>	\$150	\$934	\$157	\$37	<b>\$3,320</b>
<b>Investment Needs – 2016 through 2040</b>	<b>\$7,646</b>	\$204	\$2,458	\$376	\$112	<b>\$10,796</b>

**2.9 Quads** **4.8 Quads**

\* In Billions of dollars

# Aesthetic 'Stone' Structures



<b>Construction started</b>	<b>September 18, 1793</b>
<b>Original Completed</b>	<b>1800</b>
<b>Current Form Constructed</b>	<b>1855 - 1866</b>



# Aesthetic Durable Structures

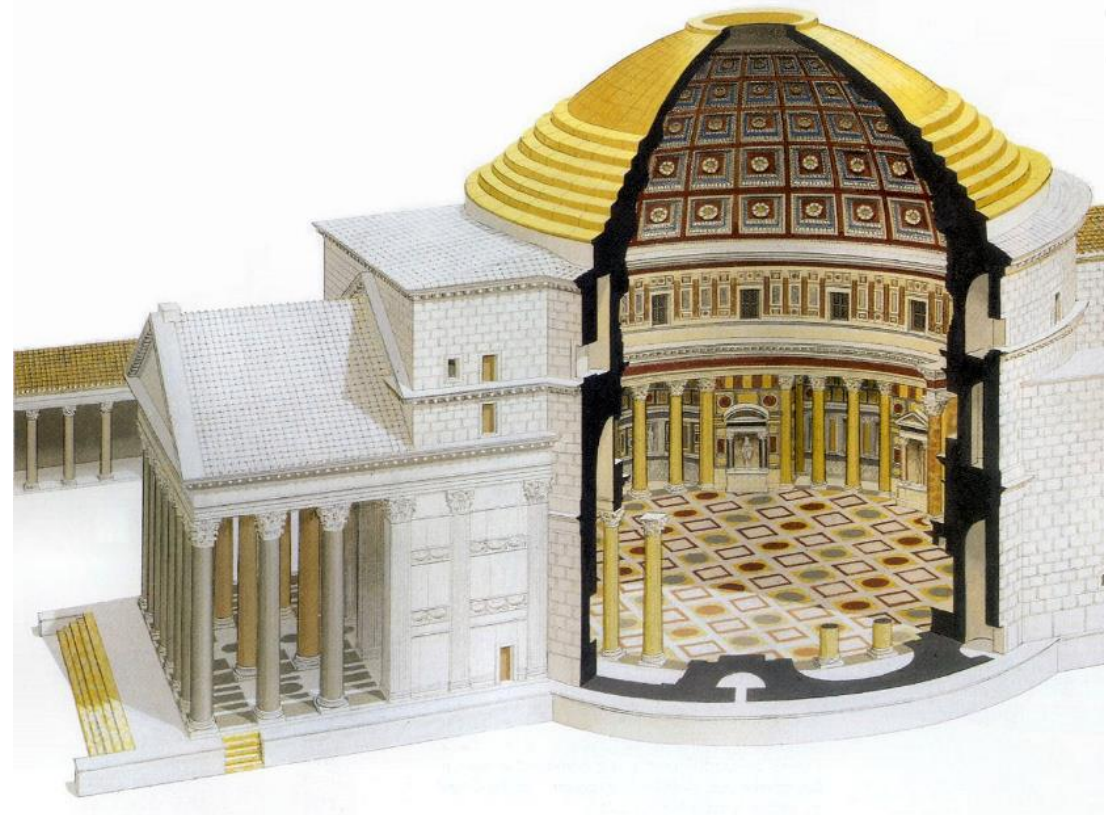


**Pantheon Construction:** 113-125 AD

# Aesthetic Durable Structures



Construction started	September 18, 1793
Original Completed	1800



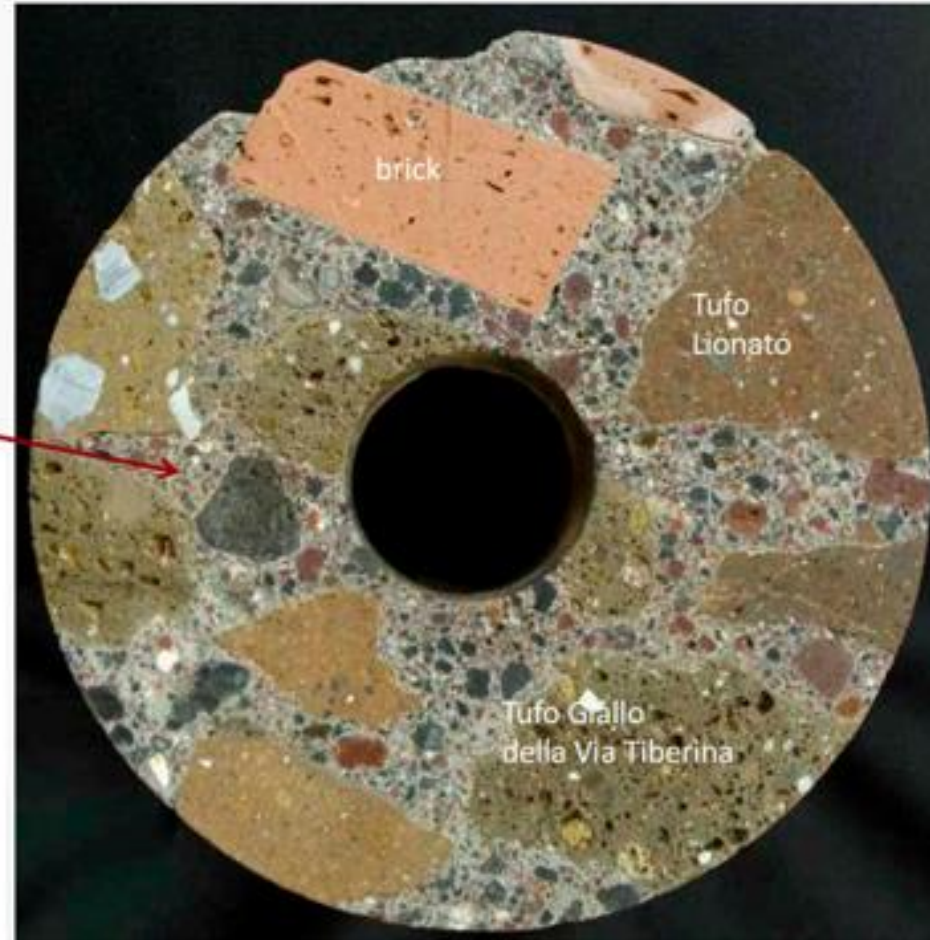
**Pantheon Construction: 113-125 AD**



# Roman Concrete Composition



Built: 100-110 AD Inaugurated: 113 AD

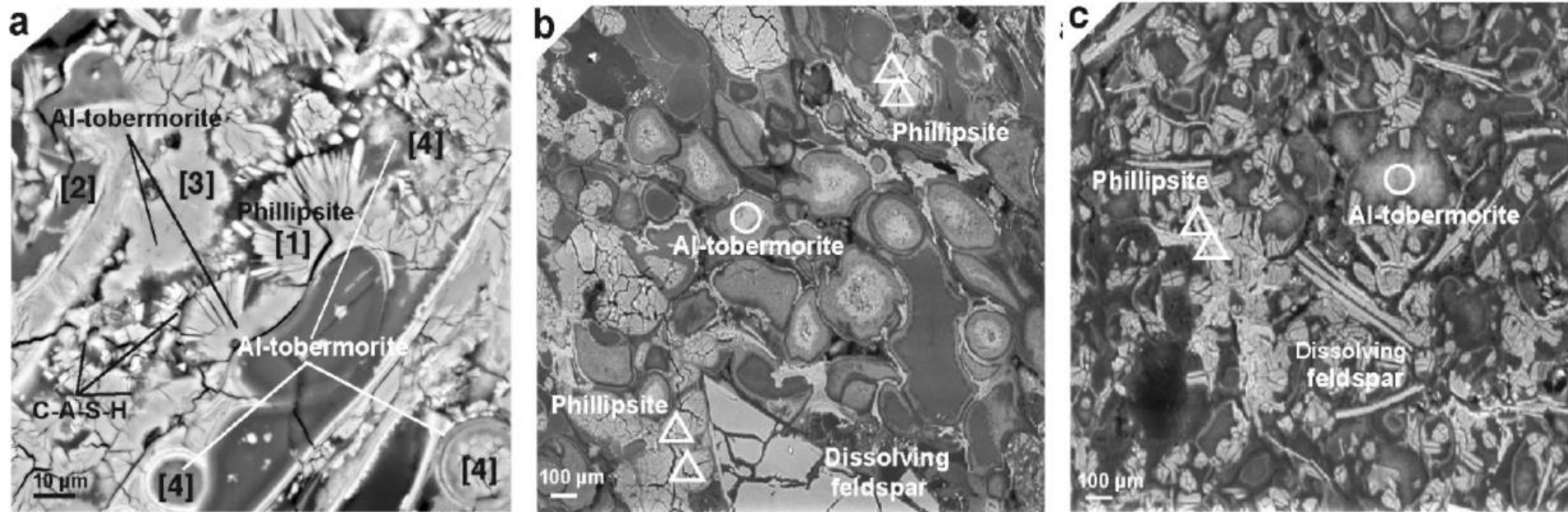
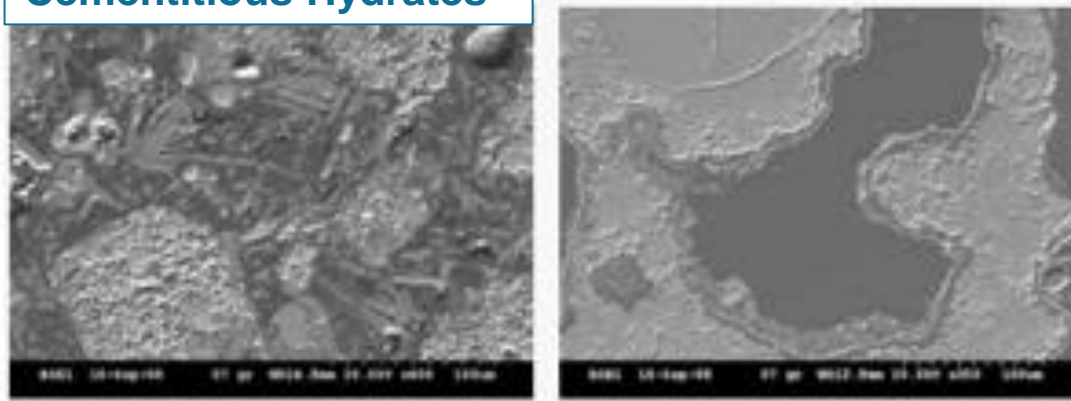


Conglomeratic wall concrete volcanic ash –  
hydrated lime mortar

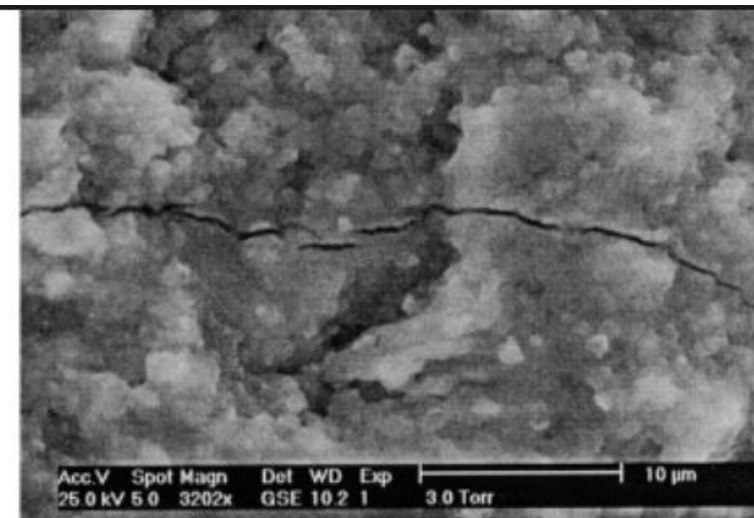
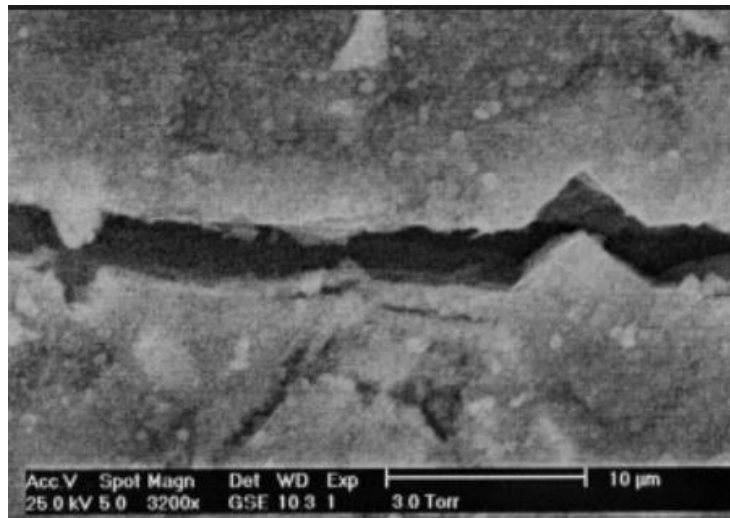
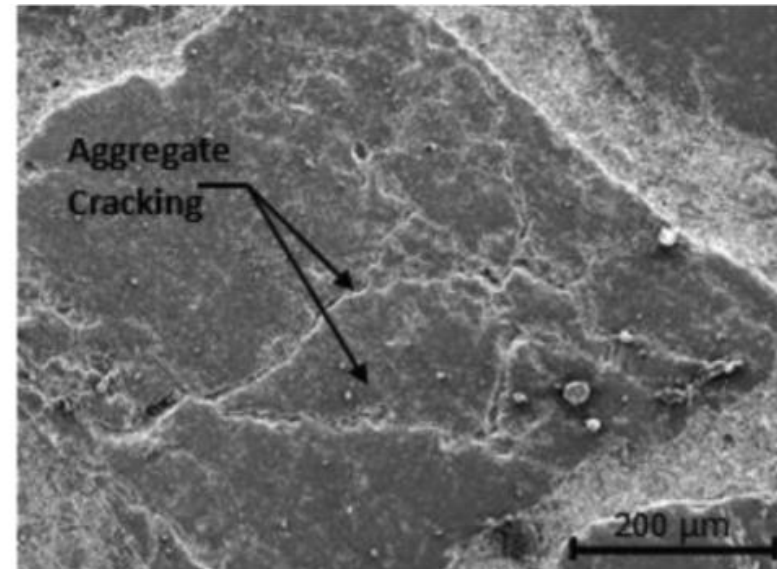
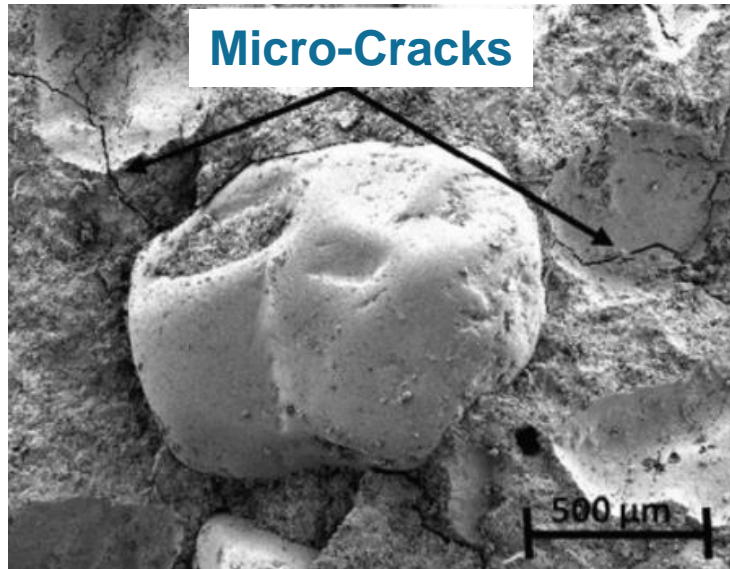


# Roman Concrete Microstructure

## Cementitious Hydrates



# Modern Concrete Micro-cracking

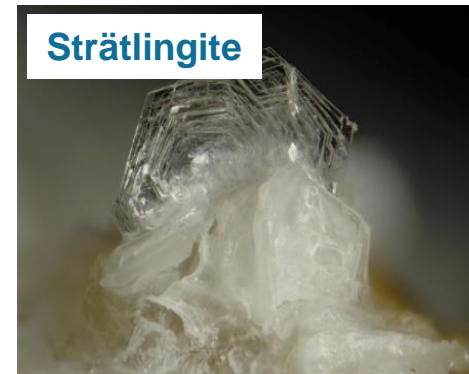




# Durability: Composition Challenge

## 1. Abiotic Compositional Approach

- i. Accelerate Novel “*in-situ*” Materials/Mineral Generation Found in Roman Concretes to Mitigate Micro-cracking:



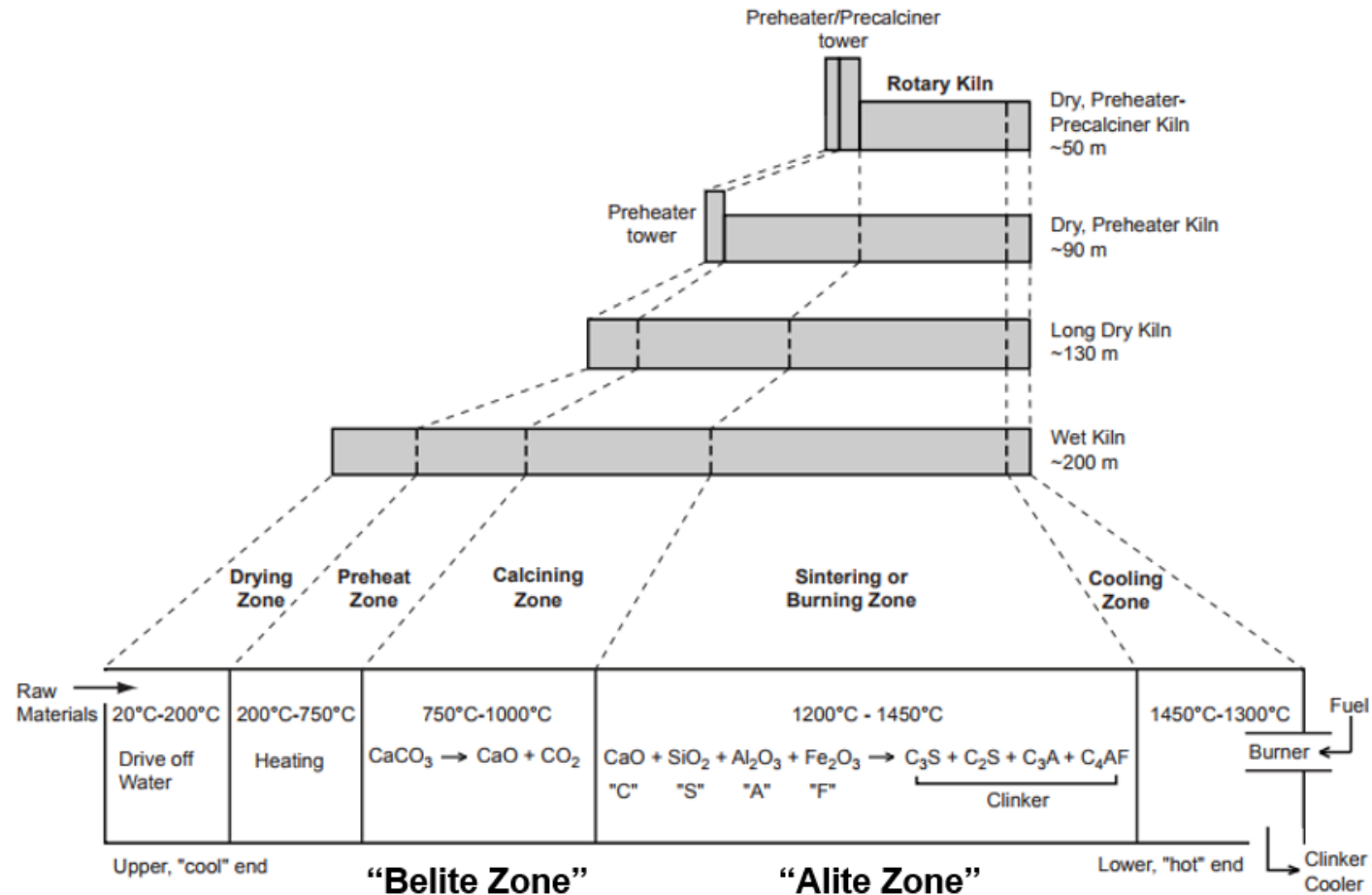




# Durability: Process Challenge

## 2. Process Approaches

### i. Kiln Process Integration, Simplification, and Hybrid Feedstocks:

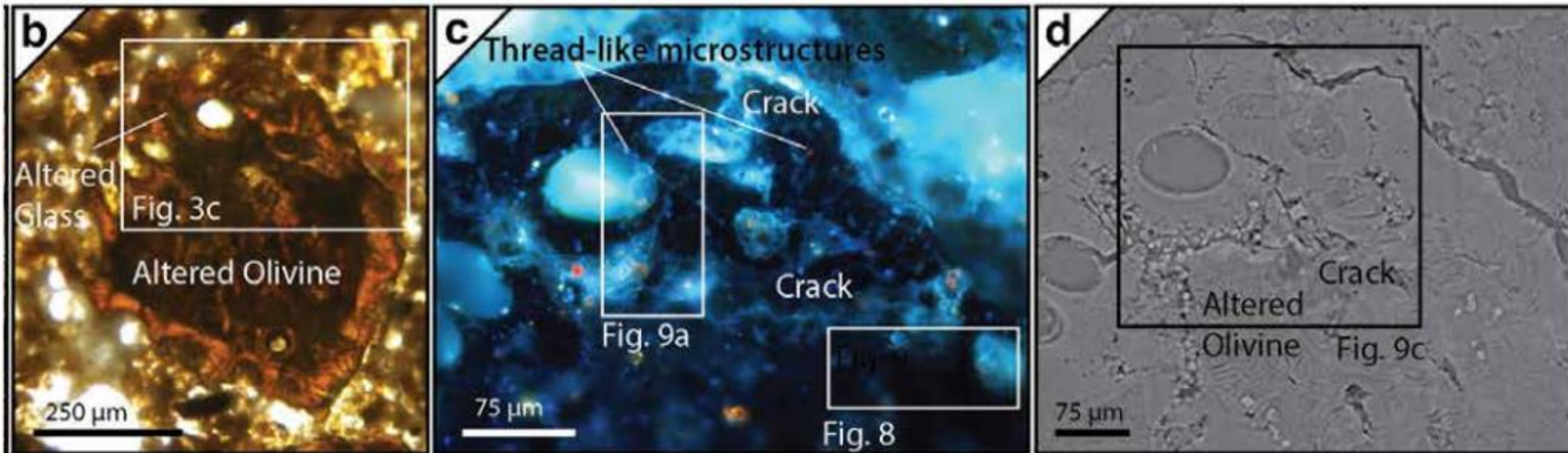




# Durability: Biogenic Challenge

## 3. Biomediated/Biogenic component or 'Self-healing' Approach

### i. Bio-deposition and Accretion



Discovered biomediated processes produce authigenic\* phillipsite and Al-tobermorite mineral cements in 15 year old basaltic tuff.

\*authigenic – minerals formed in their present position





# THANK YOU!

[joseph.king@hq.doe.gov](mailto:joseph.king@hq.doe.gov)